The effect of fire on the avifauna of subalpine woodland in the Snowy Mountains

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Abstract

The seasonal changes in abundance of bird species and individuals in subalpine woodland in the Munyang Valley were studied from 2000 to 2012. The immediate response of the avifauna to the fires of 2003 was a reduction in the number of species (from 12 to 7) and individuals (by 77%). Key to these reductions was the loss of foraging substrates that did not recover quickly, such as shrubs and the tree canopy, bark, lower branches and leaves. The general response of the avifauna was in contrast to other areas in south-eastern Australia, particularly with the slower recovery of vegetation due to low growth rates and trees regenerating from lignotuber tillers rather than epicormic shoots. The Flame Robin *Petroica phoenicea* was the first to re-occupy the woodland, with winter resident species being next to return. After ten years, the canopy had still not regrown, adversely affecting canopy foraging species, particularly seed eaters, while food sources such as flowers of *Grevillea victoriae* were not available in pre-fire amounts, slowing the return of honeyeaters. (*The Victorian Naturalist* **130** (6) 2013, 240–248)

Keywords: Snowgum, foraging, tree canopy, *Grevillea victoriae*

Introduction

The subalpine zone is that area between the timberline and the alpine treeline (Costin 1954; Körner 2012). It is an area where productivity slows on an altitudinal transect until trees reach their temperature-dependent physiological limit (Körner 2012). Pre-European fire frequency in Australian high subalpine woodland was low at about one major fire per century (Wimbush and Forrester 1988; Banks 1989; Dodson *et al.* 1994). Since European settlement, fire has been more common but still not achieving the frequency of lower more fire-prone areas. Over the course of 35 days in January/February 2003, wildfires ignited by lightning burnt through almost 85% (970 km^2) of the subalpine and alpine zones of the Snowy Mountains. These fires were the most extensive high altitude fires on mainland Australia since 1939.

In lower altitude fire-prone and fire-adapted landscapes, eucalypts have the ability to resprout after even intense fires. Unlike most angiosperm trees, *Eucalyptus* have dormant epicormic buds at the level of the vascular cambium where they are insulated beneath the bark and survive fire, allowing re-shooting from stems and branches within weeks of fire (Burrows 2002). However, the dominant mainland subalpine woodland species, Snowgum *Eucalyptus pauciflora niphophila* is sensitive to fire. The cambium near ground level is unprotected beneath thin bark and thus is generally killed even in relatively cool fires, effectively ringbarking the tree. Most of the above-ground biomass subsequently dies and one year after the widespread wildfire of 2003, 96.5% of 400 sampled trees had lost their original leaf cover (Pickering and Barry 2005). Only about 4% of these trees responded with shooting from the stem, whereas 95% responded with regenerating lignotillers (Pickering and Barry 2005). The means of regeneration, together with inherently slow growth rates at higher altitude mean that, following fire, subalpine woodland would be expected to take a long time to recover to pre-fire condition. However, lack of woodland monitoring following previous fires means that recovery times are not available.

Such a large landscape scale fire at high altitudes as occurred in 2003 has not previously been studied in Australia in relation to its impact on the fauna. It is fortuitous, therefore, that the avifauna of the area has been studied over a long period. Osborne and Green (1992) examined seasonal changes in abundance of bird species and individuals in subalpine woodland. They found that sites in woodland above 1500 m generally had only one or two species present in winter, rising to about 15 species in spring. They defined a number of foraging substrates that were regularly used by birds, many of which would be adversely affected by fire. There have been few studies that have followed the compositional changes of an avifauna through a fire event from pre-ignition to the recovery to pre-fire status (Woinarski and Recher 1997). However, the 10 km transect used by Osborne and Green (1992) was being monitored at the time of the fire (Green 2006) and was in fact walked on the morning that the fires broke out.

The present study was therefore able to follow the changes in a known avifauna. The aim of the study was to determine how the pre-fire avifauna re-established in relation to the vegetation changes that accompanied the regrowth of the subalpine woodland.

Methods

Two woodland transects in the Munyang Valley (36°20'S, 148°25'E) were studied between 2000 and 2012 (Fig. 1). One transect (T1-burnt) ran from 1500 m ASL up an aqueduct access track on Disappointment Spur (1.5 km) then ran at between 1600 and 1650 m ASL along the aqueduct itself (3.0 km). The second transect (T2-unburnt), on the western side of the same valley at 2–6 km distance from the first, ran for 2.0 km at 1580 m ASL along an aqueduct bench. Both transects ran through woodland consisting mainly of Snowgum with a canopy up to about 15 m with thick heath understorey (pre-fire only for one) for much of their length (Osborne and Green 1992).

Vegetation

For measurements of flowering of the shrub *Grevillea victoriae*, the proportion of up to 50 haphazardly chosen inflorescences of *G. victoriae* bearing open flowers was recorded at each of three sites on the burnt transect and two on the unburnt. An average was calculated for each transect (see Green 2006 for details).

Understorey vegetation height and density in woodland recovering from fire was measured at 21 sites at Smiggin Holes (1680 m) six kilometres south of the study area where the vegetation has been monitored since the 1970s. To determine vegetation cover at each site, a 3 m ranging pole marked at 200 mm intervals was used to provide a measure of vegetation structure. At each measurement point the ranging pole was placed vertically through the vegetation to the ground at the central point and at a distance of 3 m uphill, downhill and to the left and right of the central point. Any contact with a part of live vegetation within a 200 mm interval on the pole was recorded for each measurement point, giving a score for each site of between 0 and 5 for any given height interval.

Trees

Tree height was measured for 30 trees on the unburnt transect. Tree heights were calculated using measurements collected with a rangefinder and clinometer. On the burnt transect, the height of the highest regenerating lignotiller was measured for 10 trees at four altitudes in 50 m increments up Disappointment Spur and for one site on the aqueduct bench, totalling 50 trees. Height was measured using an extending pole (7 m long) with tape attached. Tree height was measured on the unburnt transect in 2008 and on the burnt transect in 2008 and 2012. Tree height on the burnt transect was essentially 0 m for 2003.

Birds

Depending on weather, the number of bird species was counted on each transect at approximately weekly intervals from the end of July to the arrival of the last regular migrant species through 2003 (Fig. 2). From 2004 to 2012 the unburnt transect was monitored weekly and at the time of maximal species numbers the burnt transect was also monitored over one to two weeks. Where possible, birds were counted on mornings with calm weather. Bird species present on the transects were identified by sight, call, and, in the case of Superb Lyrebird *Menura novaehollandiae*, by tracks in snow.

Results

Vegetation

No flowers of *Grevillea victoriae* were recorded on the burnt transect until five years post-fire in 2008 (Fig. 3). Even after this time, there were few inflorescences on shrubs and, whereas usually a single shrub was sufficient to find 10 sample inflorescences on the unburnt transect, on the burnt transect three shrubs was usually the minimum requirement. (The total number

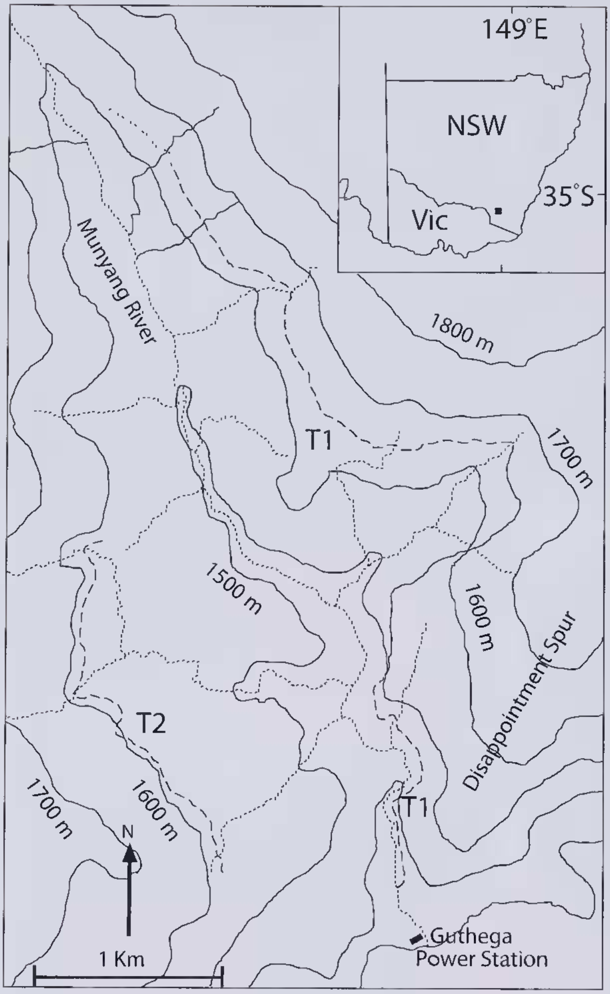

Fig. 1. Map of study area. The transects are the dashed lines; T1 (burnt) ran from 1500 m ASL up an aqueduct access track on Disappointment Spur and along an aqueduct bench at 1600-1650 m, T2 (unburnt) was on an aqueduct bench at 1580m on the western side of the valley.

of inflorescences per shrub was not counted). The general trend in flowering was no recovery until 2008 and then a reduced availability of flowers relative to the unburnt transect through the remainder of the study.

The height and density of shrubs in woodland increased slowly, with nine years elapsing before layers above 1m in height became established (Fig. 4). The ground cover <200 mm, largely grasses, was the first to recover reaching close to the maximum score of 5 by 2005 (note: there was no measurement in 2004) (Fig 4). Subsequent layers, 200–400 mm and 400–600 mm reached scores of between 4 and 5 within 10 years, with most of the recovery of 200–400 mm also by 2005. The structure of the vegetation recovered more slowly for higher layers and peaked in 2011 for 800–1000 mm and 1000–1200 mm. The shrub species responsible for most of the higher records was *Bossiaea foliosa*, a species that is favoured by fire (Good 1992), but that may senesce and thin out at about 15 years (Wimbush and Forrester 1988) with slower growing shrubs emerging beneath.

Trees

No epicormic shoots were observed on stems or branches of burnt Snowgum on the transect. Initially, post-fire, there were no shoots from the lignotubers on the burnt transect and so

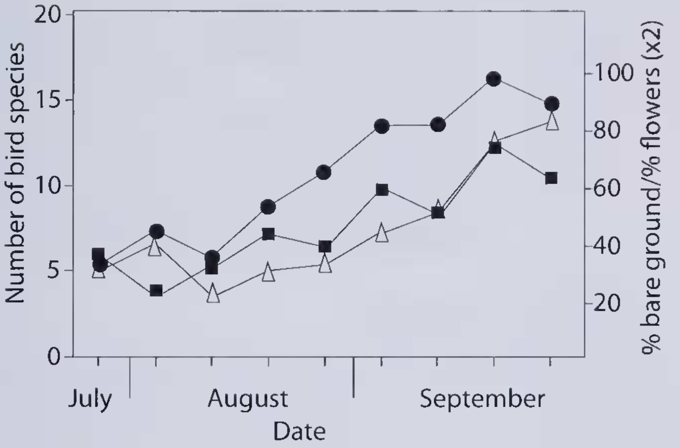

Fig. 2 Seasonal changes in average number of species of birds (circles), percentage of ground clear of snow (squares) and percentage of inflorescences of *Grevillea victoriae* with open flowers (triangles) on the unburnt transect from the last week in July to the last week of September over 10 years, 2003–2012. (Scale for flowers is x 2.0)

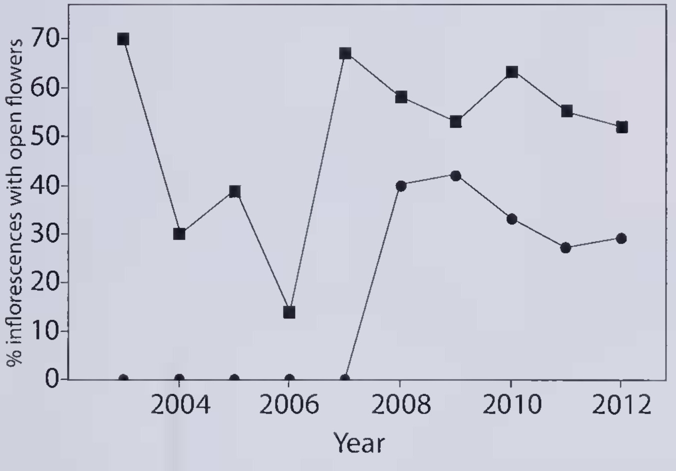

Fig. 3. Percentage of inflorescences of *Grevillea victoriae* with open flowers at the time of maximal bird species numbers on the unburnt western aqueduct (squares) and at the same time on the burnt transect on Disappointment Spur/ aqueduct (circles).

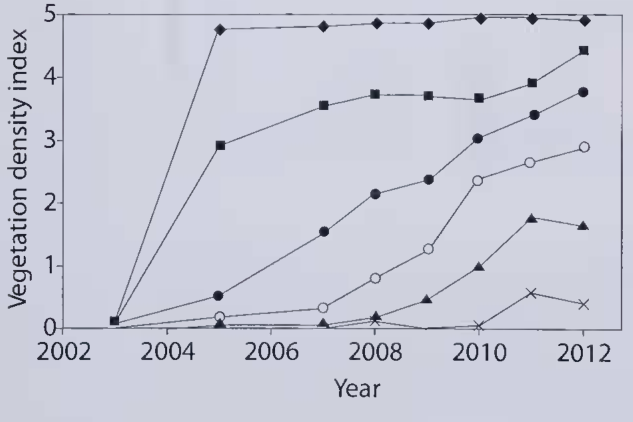

Fig. 4. Regrowth of shrub understorey in subalpine woodland by layer – each layer is 20 cm deep. The maximum possible score for any layer is 5.0 (see methods). Diamonds 0-20 cm, squares 20-40 cm, filled circles 40-60 cm, open circles 60-80 cm, triangles 80-100 cm, crosses 100-120 cm.

height was scored as zero (see Pickering and Barry 2005) but lignotillers averaged 3.18 m (±0.59 SD) in 2008 and 5.36 m (±0.93 SD) in 2012 (Fig. 5). The trees forming the canopy on the unburnt transect averaged 15.97 m (±3.1 SD). Bark still adhered to most of the burnt trees and peeled off in subsequent years until by 2012 no dead trees were observed to have adhering bark.

Birds

The species of birds recorded more than three times in the study area consisted of 15 wintering species and 14 spring immigrants (Table 1). The number of bird species on the unburnt transect was about five at the end of July, rising to about 16 species by the end of September (5.3 ±4.0 and 16.3 ±2.6; Fig. 2). For three years pre-fire the maximum number of species on the Disappointment Spur/aqueduct transect in mid to late September averaged 17.3 (±3.5 SD) and post-fire on the unburnt transect averaged 17.1 (±2.3 SD). Post-fire there were two years of lower than average numbers of bird species on the unburnt transect, with the numbers then rising to within the range pre-fire on the burnt transect (Fig. 6). There were three species of birds on the burnt transect in the spring following the fire with little change to 2006 when the number had risen to five. The rate of increase then accelerated with nine species in 2007 and 16 in 2012, bringing the number back within the pre-fire range (within 1 SD) for the first time (Fig. 6).

Two counts of 83 and 88 individual birds on the unburnt aqueduct on 20 September and 26 September 2012 gave figures of 44 and 45 birds km^{-1}. A single count on 27 September on the Disappointment Spur/aqueduct transect gave 55 individual birds at 12.2 birds per km.

Discussion

The transects used by Osborne and Green (1992) encompassed 10 km of which 6.5 km was used in the present study. Osborne and Green (1992) recorded between 17 and 22 bird species across September and October 1982 and 1983, compared with generally 17 to 19 species in the present study on the unburnt transect. Hence, in terms of species, the unburnt transect is probably a good representation of the normally unburnt state, except in the two seasons immediately post-fire when only 12 and 15 species were present (Fig. 6) possibly because the wider extent of burning affected the suitability of the general area. On the burnt transect, the immediate response of the avifauna after the 2003 fire was a reduction in the number of species and individuals (Green and Sanecki 2006). From 12 species counted on the day

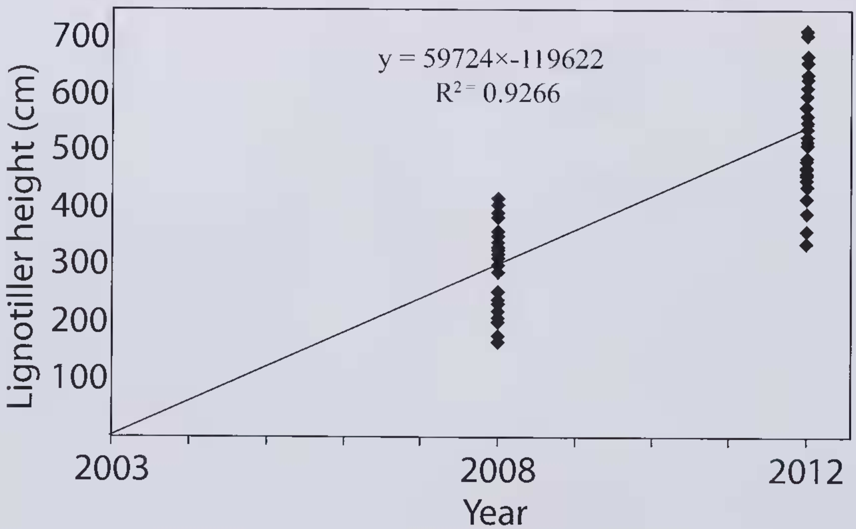

Fig. 5. Height of the tallest regenerating lignotiller post-fire on 50 trees from five locations on Disappointment Spur and along the aqueduct bench. The equation for the line and the R^2 value are shown.

Table 1. The 27 species recorded more than three times in 2003-2012 on the unburnt transects above the winter snowline together with the years in which they appeared on the burnt transect. Guilds are adapted from Loyn (1997) and are: H Honeyeaters, OI Open-ground insectivores, UI Damp-ground or understorey insectivores, UC Damp-ground or understorey insectivore/Carnivore, TI Tall-shrub insectivores, CI Canopy insectivores, CB Canopy insectivore/ Bark-forager, B Bark-foragers, C Carnivores, S Large seed-eaters, F Fruit-eaters.

Common name	Binomial		03	04	06	07	08	09	10	11	12
Red Wattlebird	*Anthochaera carunculata*	H									1
Yellow-faced Honeyeater	*Lichenostomus chrysops*	H				1	1	1	1	1	1
White-eared Honeyeater	*Lichenostomus leucotis*	H							1	1	
Brown-headed Honeyeater	*Melithreptus brevirostris*	H									
White-naped Honeyeater	*Melithreptus lunatus*	H									
Crescent Honeyeater	*Phylidonyris pyrrhopterus*	H					1	1	1	1	
Eastern Spinebill	*Acanthorhynchus tenuirostris*	H									
Flame Robin	*Petroica phoenicea*	OI	1	1	1	1	1	1	1	1	1
Pink Robin	*Petroica rodinogaster*	UI									
White-browed Scrubwren	*Sericornis frontalis*	UI			1	1	1	1	1		1
Olive Whistler	*Pachycephala olivacea*	UI				1		1	1	1	1
Superb Lyrebird	*Menura novaehollandiae*	UI								1	
Grey Currawong	*Strepera versicolor*	UC			1						
Fan-tailed Cuckoo	*Cacomantis flabelliformis*	TI						1	1	1	1
Brown Thornbill	*Acanthiza pusilla*	TI			1	1	1	1	1	1	1
Spotted Pardalote	*Pardalotus punctatus*	CI		1				1	1	1	1
Striated Pardalote	*Pardalotus striatus*	CI	1			1				1	
Grey Fantail	*Rhipidura albiscapa*	CI						1	1	1	
Grey Shrike-thrush	*Colluricincla harmonica*	CB					1	1	1	1	1
White-throated Treecreeper	*Cormobates leucophaea*	B				1	1		1		1
Laughing Kookaburra	*Dacelo novaeguineae*	C									
Pied Currawong	*Strepera graculina*	C		1		1	1		1	1	
Little Raven	*Corvus mellori*	C	1		1	1		1	1	1	1
Brown Goshawk	*Accipiter fasciatus*	V									
Gang-gang Cockatoo	*Callocephalon fimbriatum*	S									
Crimson Rosella	*Platycercus elegans*	S					1	1		1	
Silvereye	*Zosterops lateralis*	F						1			

the fire commenced on 8 January 2003 (along only 67% of the transect), numbers fell to 7 on the complete transect post-fire (Green and Sanecki 2006). Later, in May (when individuals were counted), there were four species on the transect (which is within the range previously recorded on the transects) but there were 77% fewer individuals than recorded by Osborne and Green (1992) for the same month (Green and Sanecki 2006). This is higher than the 40% reduction recorded by Loyn (1997) in a fire that was also of large extent (228 000 ha cf 700 000 ha). This is the general response of birds to fire, with a decline owing to reduction of food availability and a loss of cover (Woinarski and Recher 1997). Shrub cover was essentially zero and, where Snowgums had not lost their leaves, these soon yellowed and died due to the effect of fire ringbarking the trees (Fig 4; pers. obs.).

Although some birds may be attracted to fire (Woinarski and Recher 1997) there was little observed influx of birds to the 2003 fires at high altitudes, although in a number of fires White-throated Treecreepers *Cormobates leucophaea* were commonly heard even while fire crews were mopping up (pers. obs.).

The longer term response of birds to fires is the progressive return to the original composition of the avifauna as the vegetation recovers to its pre-fire state (Woinarski and Recher 1997). The overall post-fire response of birds in forests in eastern Victoria was an immediate reduction in abundance followed by recovery over the ensuing three years, a pattern that is general across temperate eucalyptus forests (Loyn 1997). Lindenmayer *et al.* (2008) found across 10 coastal vegetation types little effect on bird species richness persisting beyond the first year post-fire. In temperate eucalyptus woodland and forest the structural complexity recovered rapidly because of epicormic resprouting from the trunk and major limbs of trees, and this may be key to the recovery of bird numbers (Lindenmayer *et al.* 2008). In the absence of epicormic resprouting, and the dependence on slower regrowth of tree stems from a lignotuber, the general response of birds in subalpine woodland is in marked contrast to other areas in eastern Australia, particularly with the longer duration of recovery.

Immediately after the fire in burnt woodland (February 2003), the only bird species present were those that overwinter and there was a reduction in numberd of individuals to winter levels (Green and Sanecki 2006). Key to the reduction in number of bird species and individ-

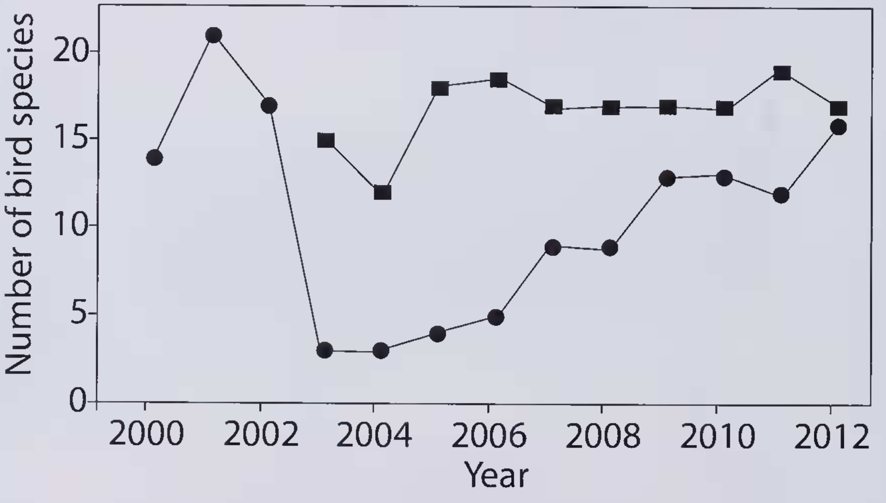

Fig. 6. Number of bird species observed at the time of maximal species numbers on the unburnt western aqueduct (squares) and at the same time on the burnt transect on Disappointment Spur/aqueduct (circles).

uals following the fire was a reduction in foraging niches. The foraging substrates that were absent, and that did not recover quickly, were canopy, lower branches and leaves, bark and shrubs. The open nature of the ground beneath the woodland attracted the Flame Robin that appeared on the transect immediately after the fire (Green and Sanecki 2006) and occurred in spring throughout the study (Table 1). The next group to recover was not so much guild-based as residency-based, with the winter resident Little Raven *Corvus mellori*, Pied Currawong *Strepera graculina*, White-browed Scrubwren *Sericornis frontalis* and Brown Thornbill *Acanthiza pusilla* all returning within the first three years, with the latter two being most noticeable on the transect.

Whilst the White-throated Treecreeper appeared immediately after the fire and the Olive Whistler appeared in the same month, these two species were thereafter absent in the early stages of vegetation recovery, the former owing to the lack of fissured bark (not present on regenerating stems) and the latter due to the lack of thick shrubs. The Grey Shrike-thrush *Colluricincla harmonica*, classified by Loyn (1997) as a canopy insectivore, but which commonly feeds on the ground and also strips bark from Snowgum and then investigates it on the snow surface (Green and Osborne 2012), was slower to return than other winter residents because of the lack of these two food sources. By the end of the ten years, the canopy still had not recovered, and sightings of the canopy insectivores Spotted Pardalote *Pardalotus punctatus*, Striated Pardalote *Pardalotus striatus* and Grey Fantail *Rhipidura albiscapa* (which forages through all strata including tall shrubs, making aerial captures) and large seed-eaters, Gang-gang Cockatoo *Callocephalon fimbriatum* and Crimson Rosella *Platycercus elegans*, were rare. This is in contrast to eastern Victoria where canopy insectivores followed the general pattern of immediate post-fire decline with rapid recovery and an apparent increase in numbers as the birds fed in new epicormic regrowth, which attracts insects (Loyn 1997).

Osborne and Green (1992) found that the proportion of inflorescences with open flowers was a significant factor influencing the number of bird species present in subalpine woodland. Whilst there was a steady regrowth of shrubs (Fig. 4) some of these took a long time to recover, and food sources such as flowers from the obligate seed regenerator *G. victoriae* were not available until 2008. This slowed the return of honeyeaters. In eastern Victoria, honeyeaters almost disappeared after fire because of loss of blossom and leaf-sucking insects but, in contrast to the present study, their numbers increased rapidly in the first year after fire, and recovered to 60% of their pre-fire numbers within three years (Loyn 1997). The absence of some of these birds would also lead to follow on effects, e.g. there would be no cuckoos if there were no breeding birds, and no breeding if there were no suitable shrubs/undergrowth available.

Bird diversity would be expected to be greater in vertically complex vegetation (MacArthur and MacArthur 1961; Recher 1969) but, after an intensive wildfire, recovery of complexity will take time if tree stems are killed. Trees took time to re-establish and it was not until two years post-fire that Snowgum seedlings and lignotuber regeneration from saplings that had lost all stems in the fire were recorded (Pickering and Barry 2005). The regrowth of woody vegetation (through epicormic shoots) and dense regrowth of shrubs in south-eastern Australia can result in population densities higher than pre-fire (Woinarski and Recher 1997), with the highest species diversity occurring 5 to 6 years post-fire (Catling and Newsome 1981). This is not the case in Snowgum woodland; the recovery to date, after one decade, has been in species numbers with a few individuals of species such as honeyeaters being able to find food, but not in the numbers found elsewhere in unburnt woodland. Density of individual birds in burnt woodland is still less than a third of that in unburnt woodland. The next phase of recovery will be the recovery in numbers of individual birds as more foraging niches become available (particularly the canopy) and the productivity of current foraging niches (such as flowers) increases. Hence the avifauna of subalpine woodland appears to have a long recovery time ahead of it.

Acknowledgments
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